SIGNAL TRANSMITTING METHOD, TRANSMITTER, RECEIVER, AND SPREAD-SPECTRUM CODE SYNCHRONIZING METHOD FOR MOBILE COMMUNICATION SYSTEM

TECHNICAL FIELD

The present invention relates to a signal transmission method, transmitter, receiver and spreading code synchronization method in mobile communication systems to which is applied a direct sequence code division multiple access (DS-CDMA) scheme carrying out multiple access using direct sequence.

BACKGROUND ART

The DS-CDMA communication method is a scheme that transmits information data after spreading their bandwidth using a code with a rate much higher than the information data rate, and its research and development have been intensively conducted to be applied to cellular systems. This is because the DS-CDMA systems have such characteristics as facilitating flexible cell design which will enable the capacity in terms of the number of users to be increased as compared with the conventional frequency division multiple access (FDMA) or time division multiple access (TDMA).

The DS-CDMA systems include two spreading methods: One carries out spreading using a spreading code called a “short code” with a period equal to that of the information symbols; and the other carries out spreading using a spreading code called a “long code” with a period much longer than that of the information symbols. As the spreading codes, Gold codes or others are used. The Gold codes consists of two M (maximum) sequences, and the Gold codes belonging to the same group can be generated by the number corresponding to its period.

Accordingly, the number of the Gold codes that can be generated is no more than that corresponding to the processing gain (PG) or spreading ratio. As a result, in the cellular systems, the same spreading code cannot be used within several cells because of interference from other cells, and this presents a reuse problem in spreading code assignment.

On the other hand, using a long code enables to generate a great number of codes by lengthening its period. Thus, each cell can assign spreading codes to users independently of the other cells in the multicellular configuration. This is because the probability is very small that the same code is used at the same time in another cell thanks to the great number of the codes.

In the cellular systems, besides the incoming radio wave traveling through the shortest path from the transmitting point, there are delayed waves resulting from reflection and refraction due to obstacles or configuration of ground such as surrounding buildings, mountains, towers, etc. Since the delayed waves usually become interference signals against desired waves, they will degrade received characteristics. In the DS-CDMA system, the information signals are transmitted as very fast signals. Thus, when they are spread to 1 MHz band, the desired waves can be separated from delayed waves with a delay of one microsecond by carrying out correlation detection at a resolution of one microsecond. Combining these waves after demodulating independently, which is called RAKE combining, has an advantage of making full use of the power of the delayed waves.

In this case, since each one of consecutive information symbols is spread by a spreading code of the same pattern in the short code system, the delayed waves with a delay beyond one information symbol cannot be combined. On the contrary, since the consecutive information symbols are spread with different portions of a long code in the long code system, the delayed waves with a delay beyond one information symbol can be RAKE combined.

Although the long code has various merits as described above, it has a demerit that it takes a long time to establish the synchronization of the spreading code. Specifically, a DS-CDMA receiver must establish synchronization of the phase of a spreading code replica at the receiver side with that of the spreading code in a received signal at the beginning of communications. Since the long code has a much longer spreading code phase to be searched for compared with the short code, much longer time is required for establishing the synchronization.

The receiver conducts the correlation detection using a matched filter as shown in FIG. **3** and a sliding correlator as shown in FIG. **4**.

(Description based on FIG. **3**)

The matched filter usually includes delay elements **1** with a delay of one chip, and spreading code multipliers **2**, the number of each of them corresponds to the processing gain. Each of the spreading code multipliers **2** can be composed of an exclusive OR (EXOR) circuit because the spreading code replica is usually binary. A spread modulation signal which has been frequency converted to the baseband with the zero IF frequency and is input to the matched filter, is delayed by the number of times of the processing gain, and they are each multiplied by a spreading code replica fed from a spreading code replica generator **3**. The resultant product signals are summed up by an adder **4**. When the phase of the spreading code in the spread modulation signal is synchronized with that of the spreading code replica, the output of the adder **4** takes a peak correlation value whose power is increased by a factor of processing gain from the average power obtained with asynchronous phases. Thus, since the matched filter detects the correlation using space integration, it has an advantage of shortening the initial acquisition time of the spreading code.

(Description based on FIG. **4**)

In the sliding correlator, a multiplier **6** multiplies the spread modulation signal by a spreading code replica generated by a spreading code replica generator **5**, and then an integrating/dumping circuit **7** performs integral of the resultant product by an amount of the processing gain. The multiplier can be composed of an EXOR because the spreading code replica is usually binary. The integral time in the integrating/dumping circuit **7** is usually one information symbol period. The integrated signal is square-law detected by a square-law detector **8** to generate its amplitude component whose value undergoes threshold decision by a threshold value decision circuit **9**. Thus, the a decision is made whether they are synchronized or not. If the integral value does not exceed the threshold value, a decision is made that they are not yet synchronized, and the threshold value decision circuit **9** controls a digitally controlled clock generator **10** such that the phase of the spreading code replica output from the spreading code replica generator **5** is updated by advancing it by J chips (usually, J=1). Thus, since the sliding correlator performs time integral, it is smaller than the matched filter in circuit scale, but takes a longer time for the initial acquisition.

As described above, the matched filter requires a shorter acquisition time thanks to the space integral, but is larger in the circuit scale. On the contrary, the sliding correlator is smaller in the circuit scale thanks to the time integral, but requires a longer acquisition time.